Multifunctional B/C Fiber Composites for Radiation Shielding

Materials Modification, Inc.

Technical Abstract

Components of lunar habitat and crew modules in the lunar vehicle are constantly exposed to hazardous space conditions, such as ionizing radiation, electromagnetic interference, orbital debris, and solar flares. The safe functioning of crew and instruments and survivability require effective radiation protection. There is also the desire to reduce the weight of parts in Space missions. In Phase I, Materials Modification Inc. developed a series of novel multifunctional composites using a proprietary high-hydrogen epoxy incorporating boron and carbon fiber layers with enhanced radiation shielding, structural, thermal and electrical properties compared with high density polyethylene (HDPE). Radiation shielding of B/C composites against high-energy neutrons were measured. The boron composites had approximately the same shielding effectiveness as HDPE and aluminum for the energetic neutrons. This is remarkable since the multifunctional properties of these hybrid boron/carbon fiber composites offer so much more than the overall properties of HDPE or Al, especially in the area of lightweight structural applications for aerospace. In Phase II, a series of composite laminates with a range of %B will be fabricated using unidirectional boron fiber and unidirectional carbon fiber in a non-autoclave process. Mechanical properties of the most promising composite compositions, including lamina and laminate properties at cryo temperature, RT, and elevated temperature will be determined. Radiation shielding studies with energetic charged particles such as, protons, heavy ions, and neutrons that would simulate conditions encountered in space will be performed. By the end of the Phase II, we would have manufactured and tested several compositions that provide optimum radiation shielding. We plan to address specific NASA mission requirements with our partners Boeing, Raytheon and Lockheed Martin who have expressed great interest in the results of the Phase I effort.

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Carbon Foam Self-Heated Tooling for Out-of-Autoclave Composites Manufacturing

Touchstone Research Laboratory, Ltd.

Technical Abstract

Touchstone Research Laboratory, Ltd. (Touchstone) has developed a novel and innovative Out-of-Autoclave (OOA) composites manufacturing process with an electrically heated carbon foam tooling system. Electrically Heated Tooling (EHT) utilizes a coal-based carbon foam (CFOAM^{REG}) core that serves as both the tool substrate and the heating source for a composite part being cured. The tool heating is a result of flowing current through the carbon foam, which results in heating. This approach to self-heated tooling is a potentially enabling technology for manufacturing large composite structures by eliminating the need for autoclaves and large curing ovens, as well as by reducing costs, weight, and improving composite part quality. The overall objective of the NASA Phase 2 program will be to optimize critical factors for thermal uniformity in a CFOAM Electrically Heated Tool (EHT) and to validate the electrically heated cure process with current state-of-the-art OOA materials. The data generated will be used to produce a Scaled Composite Shroud (SCS) cylindrical mandrel EHT that will be designed, fabricated, tested, and used to cure a large composite part without an autoclave or oven. The SCS demonstration tool will be up to an 8’ diameter and 12’ length mandrel, which will be approximately one-forth of the scale as a tool necessary for an ARES V composite structure.

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